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# INTERCOMPARISON OF STAND-ALONE AND TWO-WAY NESTED MODELS FOR CMEMS DOWNSTREAM SERVICE

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## Abstract

Prediction of hydrographic conditions e.g., sea level, temperature, salinity and currents in coastal-estuary continuum is the basis for climate change adaptation and mitigation and ecosystem-based management in coastal waters. In this study, we compare and develop two strategies: either use stand-alone Limfjord setup with boundary conditions from CMEMS or extend the CMEMS Baltic Monitoring Forecasting Centre (BAL-MFC) set-up with a nested Limfjord domain. The resolution of Limfjord domain is about 185 m horizontal resolution. This domain is not covered by CMEMS, despite its importance for sea shipping, aquaculture and mussel fisheries. The ocean model that is applied is the BAL-MFC HBM model (HIROMB-BOOS Model). The results show that both approaches are able to provide high quality sea level forecast for storm surge warning, temperature, salinity and currents with reasonably good quality for ecosystem-based management both for nested and stand-alone models. The models are able to handle the shallow thermoclines in summer as well as the strong tidal and wind driven transport through narrow straits in autumn and winter. Nested models usually have better performance and do not depend on possible change of CMEMS model that supplies boundary conditions. Nevertheless, stand-alone setup is attractive as it requires much less computational resources, can be tuned more effectively, less limits for increasing the resolution.

**Keywords:** coastal estuary modelling, two-way nesting, CMEMS downscaling, Limfjord

## 1. Introduction

Coastal estuaries and inlets are of critical importance as ecological corridors connecting terrestrial, riverine and marine ecosystems. The Limfjord is the largest Danish fjord system and extends across the Jutland peninsula from the North Sea in the west to the Kattegat in the east. HBM model with atmospheric forcing by DMI Harmonie model

(2.5 km resolution) allows for seamless transition from large scale to coastal scale by using dynamic two-way nesting [1, 2]. Nested setup [1] of Limfjord involves 4 domains, see Figure 1. The stand-alone setup has only Limfjord domain with the same resolution and boundary conditions (sea level, temperature, salinity) derived from CMEMS North Sea (west) and Baltic Sea (east) models. Nested models usually have better performance [2]. Nevertheless, stand-alone setup is attractive as it requires much less computational resources, can be tuned more effectively, less limits for increasing the resolution, etc. In order to mimic inflows at western and eastern boundaries, sea level at both sides is linearly up-scaled to increase its variation in stand-alone setup: by 20%, 3% at the western, eastern boundaries, respectively. Boundary tuning is the key factor for stand-alone setup. Untuned stand-alone model based on CMEMS boundary condition would lead to fast decline of salinity, insufficient inflows and worse performance in sea level.

## 2. Results

Sea level performance is comparable in both nested [1] and tuned stand-alone HBM setups, see Figure 1. In western part, stand-alone setup has even an advantage due to adjustment of sea level variation at the boundary. Nested setup has an advantage in middle part of Limfjord because of better inflows through narrows of Odde Sund and Sallingsund. Stand-alone setup handles better situations with low sea level as the boundary sea level is slightly increased in tuned setup leading to better performance in eastern stations.

Dynamics of salinity is governed by inflows from North sea and Baltic sea, and fresh water inflows [3]. Nested setup uses fresh water inflow by E-hype [4], but the stand-alone setup uses 62% of that value corresponding to run-off observations in Limfjord catchment in 2018-2019. Results are compared to profile observations of ODA database [3] in 22 stations, see Figure 2. Stand-alone setup results in worse performance in middle part of Limfjord due to insufficient inflows through Odde Sund and Sallingsund.

Both stand-alone and nested setups provide rather good temperature forecasts with bias and central RMSD of less than 1 degree for the 3 year period. Good thermodynamics is a key factor for applications like oyster farming in Limfjord. Stratification is rather weak in western part of Limfjord both in observations and HBM model with 23 vertical layers due to intense tidal and wind forcing.

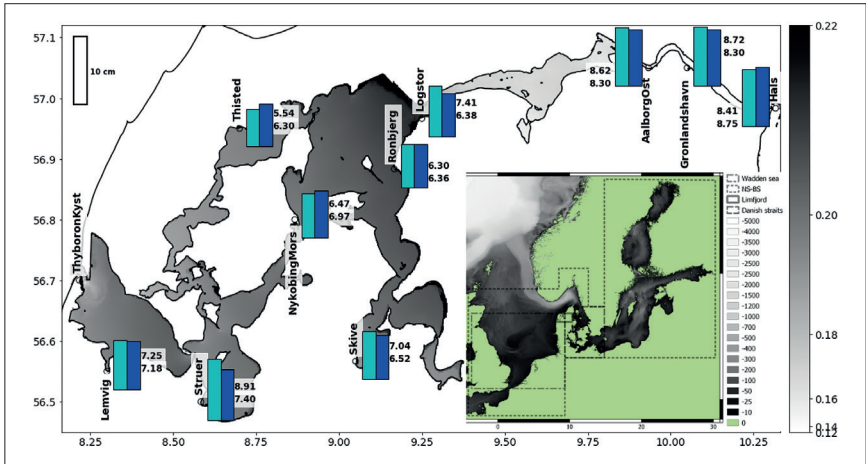


Fig. 1. Centralized Root-Mean-Square-Deviation [cm] (RMSD) of DMI's nested model (light blue, upper number) and tuned stand-alone model (dark blue, lower number) in 2017.07.01-2020.03.01. The shading shows the modelled 5 year mean sea-level. Lower-right - domains of the nested setup: North sea – Baltic sea (3 nm), Wadden sea (1 nm), Danish straits (0.5 nm) and Limfjord (185 m).

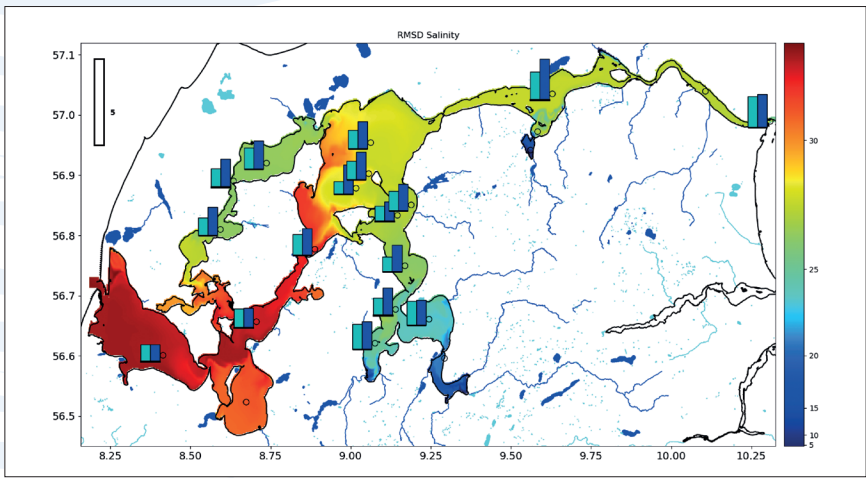


Fig. 2. RMSD of depth averaged salinity [PSU] in period 2017.07.01-2020.03.01 as compared to ODA observations. Nested model (light blue, upper number) and tuned stand-alone model (dark blue, lower number). Main rivers and lakes of Limfjord catchment are shown as blue. Colormap shows distribution of depth averaged salinity in August 6, 2017.

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